



EFFECT OF SELF-REGULATED-LEARNING STRATEGY THROUGH CHAT-GENERATIVE-PRETRAINED-TRANSFORMER ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN PROJECTILE MOTION CONCEPTS

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ABSTRACT

The problem of poor achievement in Physics in external examinations by students in Ebonyi State, Nigeria warranted the study. The need to use of a cutting-edge individualized instruction rooted in artificial intelligence to measure its potency in curbing the menace of poor achievement becomes necessary. The study examined the effect of self-regulated learning strategy through chat-generative-pretrained-transformer model4 (ChatGPT4) on senior secondary school students' achievement in projectile motion concepts. The study was guided by 2 research questions and 2 hypotheses. The design of the study was nonequivalent control groups quasi-experimental. The population for the study was 10,679 senior secondary school two Physics students in the thirty-one secondary schools for 2017/2018 academic session in Ohaukwu Local Government Area of Ebonyi state, Nigeria. The sample size for the study was 316 senior secondary school two Physics students in 4 sampled co-educational secondary schools in Ohaukwu. Projectile motion achievement test (PMAT) was the instrument used for data collection. Kuder-Richardson's formula-20 was used to determine the internal consistency reliability of PMAT. The coefficient was 0.88. Mean and standard deviations were used in answering the research questions while 2× 2 analysis of covariance was used to test the hypotheses at .05 level of significance. The result of the study showed that the students who learnt Physics using self-regulated individualized learning strategy: ChatGPT model4 achieved better than their counterparts, who learnt Projectile motion using expository method. The result of the study also showed that there was no significant difference between the mean achievement scores of male and female students who learnt projectile motion concepts using ChatGPT model4. Hence, it was recommended that Physics students should use ChatGPT model 4 which is gender-friendly to enhance their self-learning in Physics concepts.

Keywords and Phrases: Self regulated learning, Chat-generative-pretrained-transformer, Physics achievement and gender.



INTRODUCTION

Technology has changed the landscape of education in recent time. It offers new avenues for teaching, learning and engagement. One such advancement is the use of artificial intelligence (AI) models like ChatGPT to enhance self-regulated learning (SRL) strategies. ChatGPT is an acronym for chat generative pre-trained transformer. It is an AI language model developed by OpenAI. It has the capacity to understand and respond to text inputs, generating human-like conversations. Leveraging this technology in self-regulated learning can provide students with personalized support, instant feedback, and a virtual learning companion accessible anytime and anywhere. SRL refers to the ability of students to take charge of their learning process, setting goals, monitoring progress, and adjusting strategies accordingly. ChatGPT4 is the latest release of ChatGPT AI programmes. Compared to other earlier ChatGPT released models, ChatGPT4 is the best. The use of ChatGPT4 in SRL involves the learner typing the required prompt he/she wishes to find an answer for in the search engine's prompt field. The next thing the learner should do is to click the 'generate' button for automatic generation of the needed response. An example of a prompt is "What is projectile motion?" AI has the potential to transform the eld of education, and its applications are becoming increasingly prevalent (UNESCO, 2019). The massive diffusion and adoption of ChatGPT following its November 30, 2022 release suggest that AI can rapidly harness how learners learn and communicate. The release of ChatGPT generated a great deal of excitement and trepidation as to its possible effects on education (Kasneci et al., 2023). As a language model, it is a statistical model that can predict the probability of a sequence of words. With this capability, a language model can generate natural language in a human style (Fulterer, Fischer, Alekseeva, Chen, Tate, Warschauer & Gerjets (2023). It has the capacity to write stories, give life advice, even compose poems and code computer programs, when it is asked to do so (Scharth, 2022). The capability of ChatGPT4 in delivering the needed Science contents with explanations is overwhelming. Apart from composing textual data, it can solve mathematical problems in the sciences. AI is playing a role in the ever-increasing digitalization of the society (Cooper 2023). ChatGPT4 or later version is an efficient information and communications technology tool to enhance SRL. SRL strategy has been defined as a personal method that can be adopted by students to facilitate their learning and to measure progress (Ashi, 2017). It is useful for teachers and students alike because it enhances the dynamics of teaching and learning (Snyder, 2012). Snyder (2012) further maintained that SRL strategy has to do with periodic appraisal of one's thinking. Thompson (2016) in his study revealed that SRL strategy has roots in our biological makeup, which starts from the maturation of certain areas of the brain, especially the frontal lobes, that helps children to resist interference and inhibit response. It offers personalized learning experience, on-demand learning companion and improved conceptual understanding, enhanced problem solving skills, increased student engagement to task performance and knowledge-gap identification. SRL strategy helps the learner to be in charge of his/her own learning by becoming self-regulated learners. In the traditional SRL, the students were used mnemonic devices,



rhymes, rehearsal, acronyms, pegword, keyword, personal note taking, strategic questioning and other tactics in learning. Students are self-regulated to the degree that they are meta-cognitively and motivationally active participants in their own learning process (Pierce, 2011). The traditional SRL does not integrate information and communications technology tools in self-teaching and self-learning. It improves critical thinking and problem solving skills (Ronato, n.d). The integration of AI into the process of Physics learning empowers educators to establish a more vibrant and inclusive learning atmosphere, effectively addressing the persistent issues of high attrition rates, underachievement, and students' inadequate interest. ChatGPT4 improves teaching and learning of Physics (Bitzenbauer, 2023). There is a dearth of studies on the web as at the time of writing this article that measured the effect of SRL through ChatGPT4 on secondary school students' achievement in the sciences. A related study was done by Achufusi-Aka & Offia (2010) on effect of SRL on secondary school Physics students. The SRL adopted by the researchers were not rooted on AI. The result indicated that SRL group achieved better than their counterparts who were not exposed to SRL.

SRL through ChatGPT4 is anchored on Bloom's (1971) theory of individualized instruction. The theory is also referred to as the Bloom's Mastery Learning Theory. The tenets or key principles of the theory emphasize: the students learn at their own pace, clearly defined learning objectives are presented to the individual learners, mastery-based approach to self-learning, differentiated instruction which are tailored to the individual needs of the students and ongoing assessment and feedback. The theory is in tandem with the method and gender variables of the study. Comparing the tenets of the theory with the variables of the study, the idea of student learning at his or her own pace is achieved through ChatGPT4. The student decides on the prompts to write to achieve his/her will from the contents to be covered. A clearly defined learning objectives of the lesson on projectile motion is given to each student in the treatment group. Mastery learning is achieved when the student gets the correct answer based on the questions the application can pose to the student. When a student responds to questions posed by the application, there is an immediate feedback. The application is not gender sensitive. As such it develops problem solving skills among male and female users based on intelligent quotient levels. Overall, Bloom's theory of individualized instruction aims to optimize student learning by recognizing and accommodating their individual strengths, weaknesses, and learning preferences. It promotes a student-centered approach that fosters mastery, engagement, and personalized learning growth.

Despite the importance of AI, specifically ChatGPT4 in enhancing conceptual change, problem solving skills and academic engagement, Celik (2023) observed that educators are yet to maximize the potential of AI in teaching and learning contexts. The inadequate utilization of AI tools to foster learning in OhaUkwu Local Government Area of Ebonyi State, Nigeria may have accounted for students' consistent poor achievement in Physics in external examinations. The rate of poor performances among senior students in Physics has continued to increase among senior students. For instance, Jegede and



Adedayo (2013) and Ashi (2017) indicated that the rate of failure among students in Physics between 2010 and 2016 in the West African senior secondary certificate examination (WASSCE) ranged between 32% to 68%. Anibueze (2017) indicated that the percentage of candidates that got credit and above in Physics at WASSCE was 48.7%. This showed that the rate of failure was 51.3%. The level of failure prompted Physics scholars to embark on a curious search for ways of improving and enhancing the teaching and learning of Physics. Egbo (2014) pointed out that the method of instruction adopted by Physics teachers accounted for students' consistent poor achievement. The conventional method of Physics instruction has been lecture method for decades. Lecture method of instruction according to Good and Merkel (1959) adopts oral presentation of facts or principles to the learners who indulge in note-taking with little or no active participation by way of questioning or discussion in the lesson. From Loman's (1987) in Kaur's (2011) categorization of lecture types into 7: formal oral essay, expository lecture, provocative lecture, lecture discussion, lecture-recitation, lecture-laboratory and lecture-discussion cycle, none of the categories encourages individualized instruction. So, the consistent use of expository lecture is prevalent in Ebonyi state secondary schools. In this type of lecture, the teacher does most of the talking while the students listen and ask few questions. The use of expository lecture in secondary schools in Ebonyi state has been linked to poor students' achievement in Physics especially at the external examinations. Sander (2011) stated that an effective teaching method helps the students to learn better. It is difficult for the individual student to learn at his/her own rate of learning with any of the lecture types. Jegede and Adedayo (2013) noted that some Physics teachers [and students alike] fail to make use of appropriate teaching strategies that are beneficial to them. Hence, there is need to search for an appropriate teaching strategy that is based on AI which can enable an individual student optimize his/her learning to reverse the poor achievement recorded in Physics at WASSCE level.

Some topics or concepts in Physics including projectile motion have been highlighted as being responsible for the poor students' achievement in Physics at WASSCE level (WAEC, 2018 & 2019). The latest online release of WAEC chief examiners reports through e-learning platform were in 2018 and 2019 for both school and private candidates. It was reported that the Nigerian students had poor understanding of projectile motion. The students were also reported to have no proper knowledge of the applications of velocity-time graph and the mathematical relationships between acceleration and deceleration. To test the validity of projectile motion being generally classed in Nigeria as a problematic topic in secondary school Physics, the researchers visited three randomly sampled schools in the study area: OhaUkwu to measure their achievement scores in projectile motion concepts. The result of the preliminary test confirmed that the students in OhaUkwu had learning difficulties in projectile motion. There was very poor achievement in projectile motion by the students in the study area.

Another important variable in this study is gender. The gender of a student refers to as the biological function which the student can perform. Its classification is polarized:



male or female. Gender has been identified as an important variable that influences Science achievement including Physics. With respect to the use of AI SRL, specifically ChatGPT4, there appears to be dearth of studies that measured how gender influences achievement in Physics on the web. This study, therefore is set to break the horizon on the effect of AI: ChatGPT4 on gender mean achievement in projectile motion concepts of secondary school Physics.

PURPOSE OF THE STUDY

The purpose of the study was to measure the effect of self-regulated learning strategy through generative pretrained transformer (ChatGPT) model4 on senior secondary school SS II students' achievement in Physics. The study specifically sought to measure the:

1. mean achievement and standard deviation scores of students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction and their counterparts who learnt same content using expository method in the pretest and posttest respectively.
2. mean achievement and standard deviation scores of male and female students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction in the pretest and posttest respectively.

RESEARCH QUESTIONS

The following research questions guided the study:

1. What are the mean achievement and standard deviation scores of students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction and their counterparts who learnt same content using expository method in the pretest and posttest respectively?
2. What are the mean achievement and standard deviation scores of male and female students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction in the pretest and posttest respectively?

Hypotheses

The following null hypotheses, formulated at .05 level of significance guided the study:

H₀₁: There is no significant difference between the mean achievement scores of students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction and their counterparts who learnt same content using expository method in the posttest.

H₀₂: There is no significant difference between the mean achievement scores of male and female students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction in the posttest.



METHOD

The design of the study was non-equivalent control group quasi-experimental design. This design according to Nworgu (2015) is often used in classroom experiments when treatment and control groups are naturally assembled as intact classes which may be similar. This study was conducted in senior secondary schools in Ohaukwu Local Government Area of Ebonyi state. Ohaukwu Local Government Area is made up of three (3) communities; Ngbo, Ezzamgbo and Effium. The choice of Ohaukwu Local Government Area was that ChatGPT-model4 individualized instruction was new in the area and the students had poor achievement in Physics external examinations. The population for the study comprised the entire 10,679 students nested in 31 public secondary schools in Ohaukwu Local Government Area of Ebonyi State (Planning, Research and Statistics Department, Secondary Education Board, *SEB*, 2021). A total of 316 SSII students which consists of 195 students in the experimental group and 121 students in the control group were selected as the sample size for the study. Purposive sampling was used to sample 4 schools in Ohaukwu that had computer laboratories. One intact class was randomly selected from the senior secondary 2 stream in each of the 4 sampled schools. Using simple random sampling, specifically balloting with replacement, two out of the four schools were sampled as treatment group while the remaining 2 schools served as the control group. Projectile motion achievement test (PMAT) was the instrument used for data collection. The instrument was developed by the researchers, using ChatGPT4. PMAT contained 40 multiple choice items with 4 options: A – D. The items of PMAT were developed in line with the test blueprint. Three lecturers in Physics Education from Enugu State University of Science and Technology were requested to content-validate the instrument through assignment of percentages to the sub-contents of projectile motion and the latest model of Bloom's taxonomy of educational objectives: knowledge, comprehension, application, analysis, evaluation and creation. The percentage scores of the lecturers were correlated using Spearson's product moment correlation technique. The correlation coefficient obtained was .84. ChatGPT4 was instructed to create the PMAT based on one of the 3 lecturers' weightings. Kuder-Richardson's formula-20 was used to measure the internal consistency reliability of PMAT. A coefficient of 0.79 was obtained. However, the researchers did not conduct the difficulty, discrimination, distracter, carelessness indices as well as the differential item functioning of the items of PMAT.

Materials and Procedures: The materials used in the experiment included: android phones, laptops, server, Physics textbooks, chalk and chalkboard and Physics lesson notes. Before the experiment began, the researchers installed the ChatGPT4 for google as a chrome browser extension in the computers. The students received preliminary training on how to use the AI application. During treatment condition, both groups of students: treatment and control groups were individually given the contents to cover on projectile motion. For the treatment group, instructional prompts on projectile motion concepts were written by the individual student on the ChatGPT4 field and the student clicks the



'generate-response' button. Any content can be selected by the student based on his/her choice. Some of the students' generated prompts included: "ChatGPT, explain the meaning of projectile motion." "What is the acceleration of a stone projected with a velocity of 20m/s when it reaches its maximum height?" The ChatGPT model4 generates the responses based on the prompts submitted to it. The ChatGPT model4 individualized instruction group was the experimental group. The control group was exposed to expository method of instruction. They used Physics textbooks, chalk and chalkboard and Physics lesson notes. The experiment lasted for four weeks. Pretest and posttest were administered during the 1st week before treatment began and at the end of the 4th week respectively. Arithmetic mean and standard deviation were used in answering the research questions. Analysis of covariance (ANCOVA) was used to test the null hypotheses at .05 alpha level. ANCOVA was used because there was no random assignment of the research subjects into experimental and control groups. The pretest scores were also used as a main-effect in the ANCOVA analysis. The decision for the acceptance of the null hypothesis is that if the value of the calculated significance is more than .05 level of significance set for the study, the null hypothesis is accepted. On the other hand, if the value of the calculated significance is less than .05 level of significance set for the study, the null hypothesis is rejected.

RESULTS

The results are presented based on the research questions and null hypotheses that guided the study.

Research Question 1:

What are the mean achievement and standard deviation scores of students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction and their counterparts who learnt same content using expository method in the pretest and posttest respectively?

Table 1: Mean achievement and Standard deviation scores of treatment and control groups

Groups	Number	Pretest		Posttest		Gained mean
		Mean	Standard Deviation	Mean	Standard Deviation	
Treatment group	195	42.85	2.46	64.22	1.47	21.37
Control group	121	43.83	2.03	49.48	2.01	5.65

In the Table 1 above, the result of the pretest and posttest mean achievement and standard deviation scores of treatment and control groups are shown. From the Table, the pretest mean achievement and standard deviation scores for the students in the treatment group



were 42.85 and 2.46 respectively, while the posttest mean achievement and standard deviation scores were 64.22 and 1.47 respectively whereas for the students in the control group, the pretest mean achievement and standard deviation scores were 43.83 and 2.03 respectively, while posttest mean achievement and standard deviation scores were 49.48 and 2.01 respectively. From this analysis, it shows that learning took place using any of the methods. This is because the treatment and control groups achieved higher mean scores in their posttests. However, the gain in mean score was higher for the treatment group than the control. Also, the Table shows that the standard deviation score of the treatment group in the posttest was lower than the standard deviation of the control group. This means that the mean achievement score of the treatment group in the posttest was more homogeneous than the mean score of the control group, which had higher standard deviation score.

Research Question 2:

What are the mean achievement and standard deviation scores of male and female students who learnt projectile motion concepts using ChatGPT4 individualized instruction in the pretest and posttest respectively?

Table 2: Mean achievement and standard deviation scores of male and female students taught projectile motion concepts using ChatGPT4 in the pretest and posttest respectively.

Group	Gender	Number	Pretest		Posttest		Gain Score
			Mean	Standard Deviation	Mean	Standard Deviation	
Treatment	Male	94	43.15	2.49	56.19	1.07	13.04
	Female	101	42.49	2.47	55.91	1.06	13.42

Table 2 above displays the result of the pretest and posttest mean achievement and standard deviation scores of male and female students taught projectile motion concepts using ChatGPT4 in the pretest and posttest. The pretest mean achievement and standard deviation scores for the male students in the treatment group are 43.15 and 2.49 respectively. The posttest mean achievement and standard deviation scores are 56.19 and 1.07 respectively. For the female students, the pretest mean achievement and standard deviation scores are 42.49 and 2.47 respectively, while their posttest mean achievement and standard deviation were 51.91 and 1.06 respectively. From the Table, it shows that the pretest and posttest mean achievement and standard deviation scores of the male and female students are very close in the pretest and posttest levels. This means that the mean achievement scores of the female students were homogeneous at pretest level. However, the posttest mean scores are more stable than the pretest mean scores. The gain score in mean achievement of male is 13.04 while the mean achievement gain of female is 13.42.



The gain scores in achievement mean for male and female sub-samples appear approximately equal.

HYPOTHESES:

Ho₁: There is no significant difference between the mean achievement scores of students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction and their counterparts who learnt same content using expository method in the posttest.

Table 3: Analysis of covariance for the pretest, method and gender main-effects,

Source	Type II Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	178039.371 ^a	4	44509.843	1035.807	.001	
Intercept	8716.942	1	8716.942	202.856	.004	
PRETEST	174574.904	1	174574.904	4062.605	.120	NS
METHOD	2976.161	1	2976.161	69.259	.007	S
GENDER	627.557	1	627.557	14.604	.155	NS
Error	16028.248	373	42.971			

KEY: S-Significantly different, NS-Not significantly different. a. R Squared = .917 (Adjusted R Squared = .914).

Table 3 shows the analysis of covariance (ANCOVA) results of the pretest, method and gender main-effects. The significance value attached to the F-value of 4062.605 for the pretest main-effect is .12. The significance value of .12 is greater than .05 set for the study. Thus, there was no significant difference between the pretest mean achievement in the treatment and control groups. This means that the two groups were approximately equal in abilities before treatment began. For the method main-effect, the significance value attached to the F-value of 69.259 is .007. The significance value of .007 is less than .05 set for the study. Thus, the null hypothesis was rejected. Therefore, there was a significant difference between the mean achievement scores of the treatment and control groups, in favour of the treatment group with a higher mean score. This means that the students exposed to self-regulated individualized learning using ChatGPT4 performed better than their counterparts exposed to expository method.

Ho₂: There is no significant difference between the mean achievement scores of male and female students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction in the posttest.



From the result in Table 3, it is observed that the significance value attached to the F-value of 14.604 for gender main-effect is .155. The significance value of .155 is more than .05 set for the study. Thus, the null hypothesis which says that there is no significant difference between the mean achievement scores of male and female students who learnt projectile motion concepts using ChatGPT-model4 individualized instruction in the posttest was accepted. Therefore, there was no significant difference between the mean achievement scores of male and female students in the treatment group. So, the use of ChatGPT4 individualized instruction enhanced equality in projectile motion concepts achievement between male and female sub-samples.

DISCUSSION OF THE FINDINGS

It was found out from the results of the study that there was a significant difference between the mean achievement scores of students who learnt projectile motion concepts through self-regulated learning, specifically using ChatGPT4 and their counterparts who similar secondary school Physics contents using expository method. The significant difference was in favour of the treatment group. This finding is line with Snyder (2012), who remarks that self-regulated learning strategy is a periodic appraisal of one's thinking skills. Thompson (2016) maintained that self-regulation learning has roots in student's biological makeup, which starts from the maturation of certain areas of the brain, especially the frontal lobes, that helps the student to resist interference and inhibit response. The finding therefore, is useful to the study because it has provided the Physics teachers with an additional strategy in teaching of Physics topics that will enhance a better assimilation of Physics. As an individualized instruction that is rooted in artificial intelligence, ChatGPT4 has the potential of allowing the students to manage their own Physics learning. When students manage their own learning, there is a higher propensity to engage in the learning task. It boosts intrinsic motivation and situational interest of the learner too. This can lead to the development of problem solving skills and higher achievement gains. The interaction between the individual learner and ChatGPT4 mimics real-life teaching where textual ideas are shared between the teacher and learner. The result of this study is also attributed to the fact that the use of textbooks in the conventional expository method of instruction may not actually predispose the students to correct scientific phenomenon, considering the fact some texts are written with errors. The use of ChatGPT4 in Physics learning has authenticated the Bloom's (1971) theory of individualized instruction. The theory posits that for meaningful learning to take place, students should: learn at their individual rates, be given defined learning objectives, be exposed to mastery and differentiated learning. All these critical issues in meaningful learning are taken care of by artificial intelligence (AI) system like ChatGPT4.

The finding further showed that there was no significant difference between the mean achievement scores of male and female secondary school students who learnt projectile motion concepts in Physics when taught with self-regulated-learning,



specifically through ChatGPT4. This finding shows the capacity of AI, specifically ChatGPT4 to address the issue of gender-divide in teaching and learning of secondary school Physics concepts. The need to fill the gender-gap in Physics achievement is paramount to any nation's science and technological development. There exists gender-gap in Physics enrollment. Since AI has the potency to equalize projectile motion concept achievement in secondary schools, in Ebonyi state, Nigeria, it stands a chance to correct gender inequality in Physics enrollment in the area.

SUMMARY AND CONCLUSION

From the above findings, the study concluded that self-regulated-learning strategy specifically using ChatGPT4 is better than expository lecture in enhancing academic achievement in projectile motion concepts. More so, the study found out that there was no significant difference between the mean achievement scores of secondary school male and female students in projectile motion concepts when they taught using ChatGPT4.

RECOMMENDATIONS

Based on the results of the study, the following recommendations are made:

1. The Physics students should avail themselves of the opportunity provided by ChatGPT4 to individually learn Physics concepts.
2. ChatGPT4 should be introduced to secondary schools in Ebonyi state as a way to ensure gender equality in Physic achievement.

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